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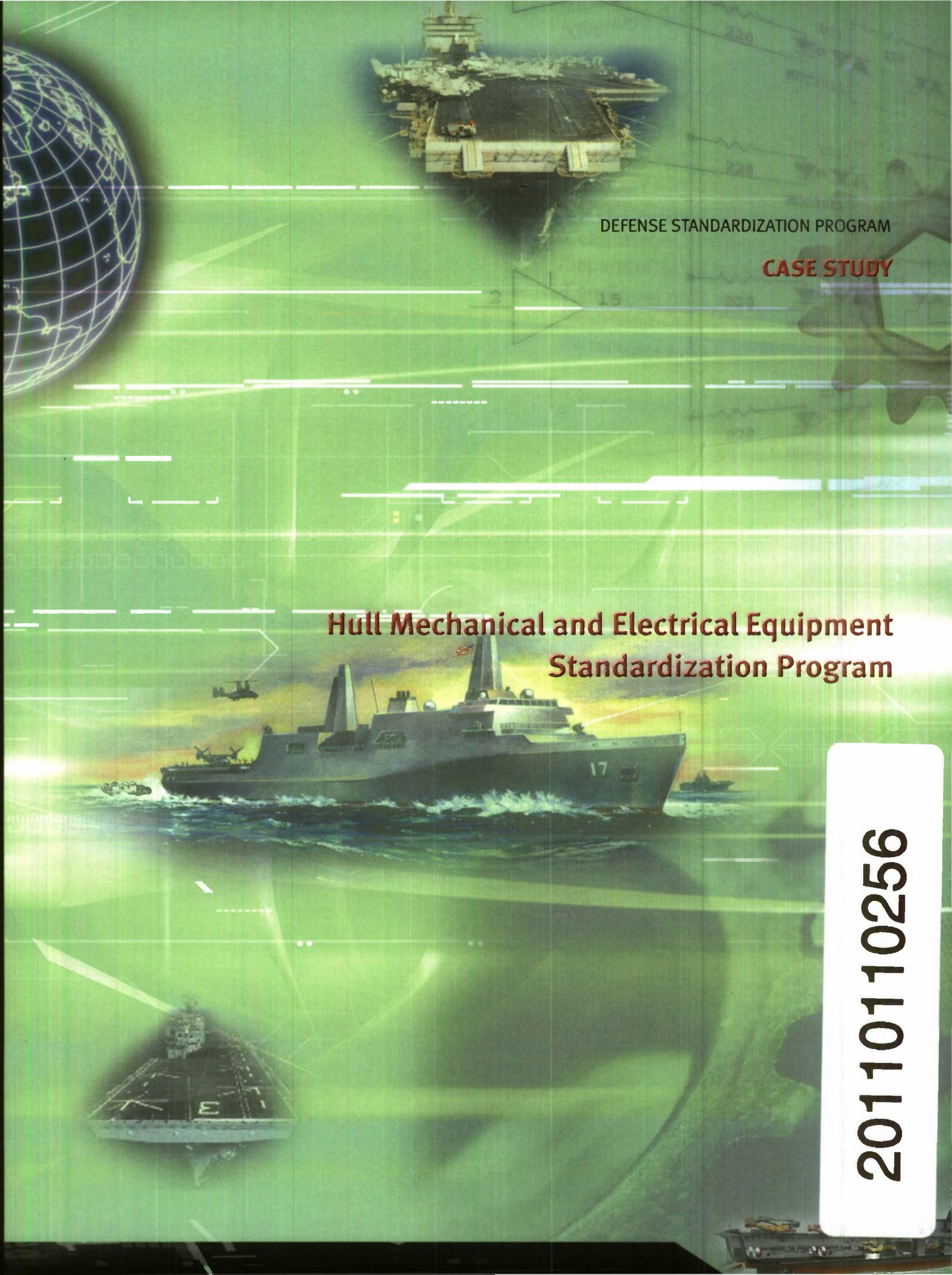


DEFENSE STANDARDIZATION PROGRAM

CASE STUDY

Hull Mechanical and Electrical Equipment Standardization Program

This case study describes how the Navy is dramatically increasing standardization of hull mechanical and electrical (HM&E) equipment across Navy ships, thereby conserving money, manpower, and time, while improving the operational readiness and availability of the fleet.

Hull Mechanical and Electrical Equipment Standardization Program

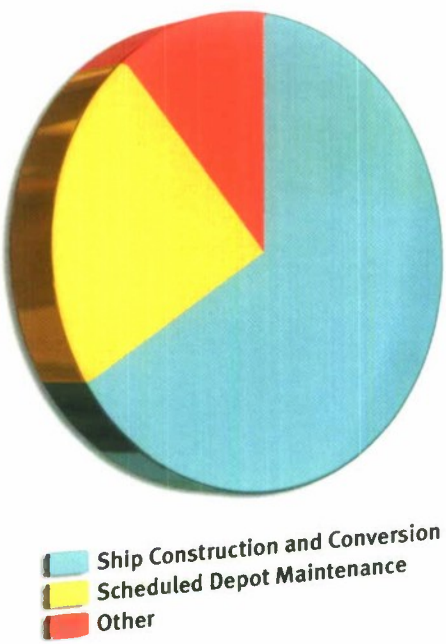
BACKGROUND

In the 1980s, the Navy[1] began examining the proliferation of HM&E equipment. Why, for example, was the Navy managing multiple unique pumps when a single pump could meet the requirements of several ships?

In a 1988 study, the Navy found that proliferation of allowance parts lists (APLs)[2] for like items of HM&E equipment had reached unacceptably high levels, causing significant support problems. The fleet had more than 180,000 different types of HM&E equipment, each supported by individual parts lists, technical manuals, preventive maintenance documents, training courses, and training equipment. Moreover, some 8,700 new HM&E APLs were generated each year, resulting in the annual assignment of more than 28,000 new national stock numbers (NSNs), which added to the already voluminous list of logistically managed supply items.

As shown in Figure 1, two activities—ship construction and conversion, and scheduled depot maintenance—generated nearly 90 percent of all new APLs and NSNs. Ship construction and conversion alone accounted for 66 percent of the new APLs. Furthermore, 50 percent of all HM&E items (e.g., a unique pump) were installed on three or fewer ships and had a total inventory of seven or fewer installed units across the entire naval fleet. The existence of APLs and NSNs for nonstandard, low-population HM&E components increased life-cycle cost and reduced operational flexibility and availability to the fleet.

FIGURE 1. Activities Generating New APLs



Navy managers, faced with the need to reduce operating and life-cycle costs, are now required to select shipboard systems, equipment, and components based on total ownership cost (TOC), rather than the initial acquisition cost alone. Although initial acquisition cost remains important, additional life-cycle factors such as manning, reliability, maintainability, and availability must be considered if the lowest practicable TOC is to be achieved. Standardization can result in significant reductions in the number of repairable items. Combined with the deliberate use of common items in ship design, standardization can produce substantial cost savings over the life cycle of ships.

PROBLEM

The proliferation of HM&E equipment was fueled by a number of factors:

- *Lack of engineering awareness and responsibility for life-cycle costs.*
  Many working-level engineers were simply not aware of the impacts on logistics support activities of selecting nonstandard equipment. Moreover, program managers were primarily concerned with the initial acquisition and delivery of the ship rather than with life-cycle costs.
- *Lack of data access.*
  Engineers lacked the tools to readily access current and accurate data on the performance, logistics, and cost of commercial equipment. They also lacked clear guidance regarding how HM&E equipment selections affect logistics and life-cycle costs.
- *Acquisition incentives.*
  Unless contractually obligated or greatly incentivized to select equipment based on best life-cycle cost, the shipbuilder awards equipment contracts to the low bidders or to regional suppliers. This practice resulted in thousands of new equipment items being unnecessarily introduced into the Navy supply support system and less-than-optimum life-cycle costs being incurred by the government.
- *Obsolescence.*
  Many equipment items, especially electronic items, are subject to obsolescence due to rapidly advancing technologies that provide increased performance and cost efficiencies. To a lesser extent, this also is true with HM&E items because manufacturers continually improve the equipment, changing the configuration and hence the technical data package. Often, such changes require generating a new APL number in the Navy logistics support system.
- *Manufacturer turnover.*
  The turnover among original equipment manufacturers is considerable; they go out of business entirely or undergo mergers and buyouts. The discontinuation of a manufacturing line forces shipbuilders and suppliers to find alternative sources, which often results in the introduction of new HM&E APLs and increased TOC.

- *Navy market share.*
  The Navy's influence on the commercial market has been in decline for several years as it downsized the fleet. The Navy's share of the shipbuilding market relative to the world market is too small to induce manufacturers to make equipment that meets Navy requirements. The Navy's share of the marine equipment market is significant only for Navy-unique equipment, such as replenishment and fueling-at-sea systems and components and equipment built specifically for combat systems or to withstand strict shock requirements.

Approach

Since the late 1980s, the Navy has focused its HM&E standardization program on ship construction and conversion. To reduce the unnecessary introduction of new HM&E equipment—in other words, to reduce the number of unique or nearly unique HM&E APLs—the Navy has worked aggressively with contractors and managers of major ship acquisition and equipment procurement programs. The Navy established the following HM&E equipment standardization goals:

- Reduce, to the greatest extent possible, the number of sizes and types of equipment that have similar functions
- Provide for common usage of equipment, parts, and materials to promote commonality among weapons systems
- Maximize the use of standard design equipment, parts, materials, and processes to lower costs, reduce downtime, facilitate interchangeability, enhance maintainability, and promote commonality
- Maximize repetitive use of existing, reliable, and fully supported equipment
- Maximize the use of common publications, manuals, drawings, training aids, and similar materials
- Conserve money, manpower, time, facilities, and natural resources
- During the system design, redesign, or production stage, exclude, to the maximum extent practical, equipment that is not fully supported
- Improve operational readiness and availability of the fleet
- Reduce the life-cycle logistics support costs of equipment.

The Navy's standardization approach is aimed at the use of systems, equipment, and components, both within ship classes and across ship types, that are standardized to the maximum extent practicable.[3] Hence, standardization is divided into tiers:

- *Intraship commonality.*
  The first-tier objective is to ensure the use of identical equipment for similar functions on a single ship.
- *Intraclass commonality.*
  The second-tier objective is to attain the maximum level of interchangeability of equipment and components by reducing the number of unique items for like functions installed within the ship class.
- *Intrafleet commonality.*
  The third-tier objective is to obtain commonality with existing supported equipment and components across different ship classes within the fleet while meeting all performance and other requirements.

Objectives affecting all tiers include limiting the range of different types of equipment and components used and provisioning for the maximum use of common maintenance, test, and sup-

port equipment and training material at the minimum total logistics support cost.

To achieve those goals and objectives, the Naval Sea Logistics Center's HM&E Standardization Office focused on two major efforts:

- HM&E Equipment Data Research System (HEDRS), developed in the late 1980s and early 1990s, which provides access and insight into the performance, logistics, and cost data required to select the right equipment
- Navy Standardization Guide (NSG), a desk guide that summarizes current HM&E standardization policies and data and provides templates for developing a standardization program plan.

The two efforts address some of the key factors contributing to the proliferation of HM&E equipment, notably, the lack of engineering awareness and the lack of data access. They also moderate the effects of obsolescence and manufacturer turnover. Together, they improve designers' and engineers' awareness of and ready access to equipment TOC databases and tools that provide the information necessary to enable the selection of best-value equipment.

HM&E Equipment Data Research System

The Navy's primary tool for standardizing HM&E equipment during the 1990s has been HEDRS, a collection of databases and analytical programs. With HEDRS, maintenance, operations, engineering, planning, and logistics communities can research HM&E equipment data and resolve emergent or anticipated problems. For official use only, HEDRS was produced and distributed annually on compact disk and was provided as government-furnished equipment in ship construction contracts.

Now, HEDRS brings enhanced data and analytical capability directly to the fleet. Two Navy products, HEDRS and SeaLink, constitute one web-based product available via a password-protected Internet site.[4] HEDRS is available through the Naval Sea Logistics Center home page (www.nslc.navsea.navy.mil) and the Navy's Distant Support Anchor Desk (www.anchordesk.navy.mil), the fleet's single point of access for technical problems, logistics help, supply questions, and ordnance issues.

HEDRS contains unclassified information on approximately 150,000 HM&E nondevelopmental items installed in the fleet that warrant the assignment of an APL number. The majority of previously available reference systems concentrated on part number/stock number relationships, but had very little information on the end-item equipment. HEDRS includes four databases:

- Components Characteristics File, which describes form, fit, and function attributes and is indexed by APL number
- Equipment Applications File, which documents where within a particular ship the equipment is installed
- Supportability Database, which contains information derived from a manufacturers survey and expressed in terms of an engineering support code[5,6]
- Integrated Logistics Support (ILS) Database, which reports whether ILS data have been developed for the particular equipment.

HEDRS also contains data about equipment populations in the fleet.

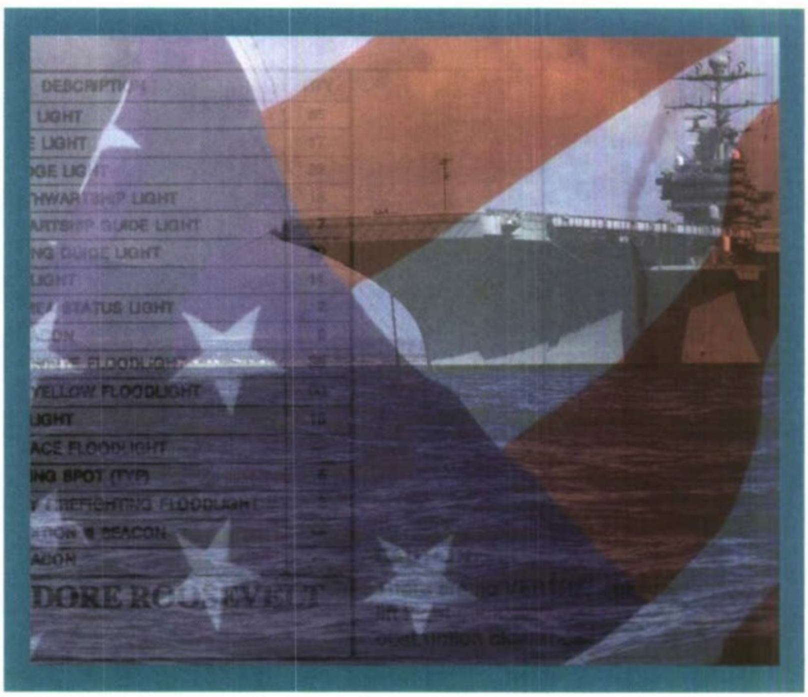
HEDRS has user-friendly features that enable users to query, retrieve, analyze, and store data for specific situations. Examples of analyses that can be performed using HEDRS follow:

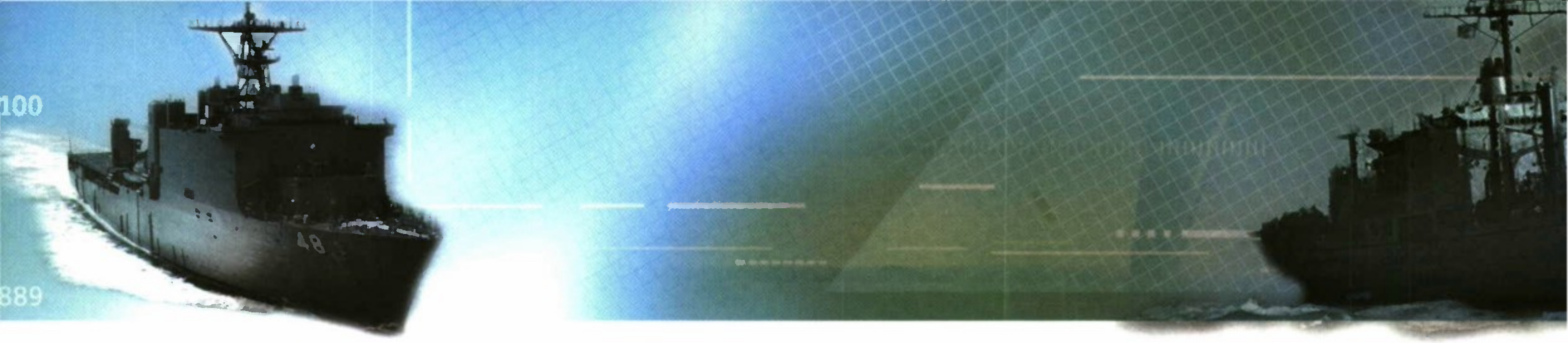
- *Feasibility of equipment substitution.* If equipment replacement is required, a user can query HEDRS, using component characteristics data of the equipment to be replaced, to find equipment installed in the active fleet that meets the desired specifications and is supported by the original equipment manufacturer. This ability is one of the most powerful utilities in HEDRS.
- *Identification of potential problem equipment.* A user can identify HM&E equipment that is obsolete, obsolescent, or foreign-source dependent.[7] Once such equipment is identified, the user can further investigate and possibly replace the equipment. This capability is essential in helping programs avoid selecting equipment that will cause problems downstream.
- *Application of the equipment.* A user can identify all HM&E equipment APLs installed on a particular ship and can retrieve a breakdown by equipment category (valve), equipment class (relief valve), or service (main propulsion boiler safety relief valve). The user also can determine the application of specific equipment across the fleet.

Navy Standardization Guide

Another critical tool is the NSG. Developed to aid in training and awareness, the NSG is a simple, easy-to-use guide addressing current HM&E standardization policies and data. The NSG conveys the importance of selecting standard parts and equipment in the design process. It summarizes the policies that support standardization and organizes the ideas from many documents to help managers better implement standardization in their programs.

The NSG contains several standardization program planning documents, including military handbooks, DoD directives, SECNAV instructions, and sample standardization program plans. It also contains standard profile reports (SPRs) and an ILS cost-avoidance package that includes ILS cost tables and a cost calculator. The SPR provides indicators of HM&E standardization by ship, ship class, and the entire active fleet by listing the number of times an APL is used throughout the fleet. Managers can use an SPR to determine the relative degree of standardization for HM&E equipment used in the fleet.





The ILS cost calculator is a repeatable method, validated by the Naval Audit Service, for evaluating the life-cycle costs associated with a program's equipment needs. The calculator helps to identify and quantify the life-cycle costs that should be considered in an economic analysis relevant to the competitive procurement of functionally interchangeable equipment. The ILS calculator accounts for the following logistics support costs:

- Development and assembly of technical documentation
- Provisioning
- NSN/APL maintenance
- Training
- Technical manuals
- Installation drawing changes
- Configuration control
- Testing
- Planned maintenance.

Given known factors for particular equipment, such as number of parts, expected life cycle, unit price, and number of classes of ships receiving the equipment, a program manager can compare life-cycle costs for interchangeable equipment.

Standardization Achievements

As a result of its HM&E standardization program, the Navy has dramatically reduced the unnecessary introduction of new HM&E equipment in the fleet. In the following subsections, we described the significant achievements in standardization that have occurred in two classes of ships—amphibious assault ships (LHD) and amphibious transport dock ships (LPD)—and in the overall fleet.

Amphibious Assault Ships

A study of the construction of the LHD 1 amphibious assault ship class revealed poor standardization results—only 60 percent of the HM&E equipment used in the LHD 1 was already in the Navy's fleet inventory at that time. LHDs 2, 3, and 4 were built using the same approach—one that relied on monetary incentives to achieve standardization—and with the same disappointing results.

It was clear that a new approach was needed. So beginning with con-

Market Research Yields Better Standards

The LPD 17 baseline system description called for a standard Navy saltwater strainer—large and cumbersome equipment that must be manually cleaned, a time-consuming process. The logisticians and design engineers conducted market research to select an alternate: a Navy-standard self-cleaning saltwater strainer that offers higher operational availability with full functionality. Cleaning occurs in 30 seconds without disassembly. The strainer also has a smaller space and weight profile. By selecting an alternate standard, the Navy estimates a $12 million cost avoidance for the 12-ship class over a 40-year life cycle.

struction of LHD 5, and continuing with LHDs 6 and 7, the Navy used the LHD Class Standardization Program Plan and HEDRS, along with monetary incentives, to achieve dramatic improvements in standardization.[8]

The LHD Class Standardization Program Plan required the shipbuilding contractor to maximize the use of equipment and components on the following lists (in order of precedence):

- Navy Standard Design List, a list of Navy-wide equipment for which the Navy has developed a complete technical data package, including production drawings for manufacturing
- LHD Class HM&E Supportable Equipment List, a list of equipment installed on LHD 1 and LHD 2 and fully supported by the Navy or the original equipment manufacturer
- HM&E Supportable Equipment List, a list of additional HM&E equipment used in the Navy and fully supported by the Navy or the original equipment manufacturer.

The contractor also was required to achieve the maximum level of interchangeability of equipment and components by reducing the number of unique items of like function installed in the ship (intraship standardization). All requests for nonstandard equipment—that is, items not contained in the above three lists—were submitted to the Navy for approval. The contractor submitted quarterly progress reports to demonstrate the degree of standardization being achieved during the design and construction of the ship. These reports provided the program manager real-time insight into the level of standardization being achieved and was critical to the success of the program.

The LHD Class Standardization Program Plan required that all selected HM&E equipment and associated spare and repair parts be available either from the original equipment manufacturer or through the Navy. In addition, the plan required that all HM&E equipment have a minimum of five applications (on one or more ships) throughout the fleet. These requirements helped to moderate the issues of manufacturer turnover and obsolescence.

The standardization results for LHDs 5, 6, and 7 were dramatic in terms of intraship, intraclass, and intrafleet standardization. The number of new HM&E equipment items introduced into the fleet as a result of the construction of these three ships was significantly lower than that of the four earlier LHD-class ships. Table 1 compares standardization results for the LHD 1 and LHD 7 based on FY02 data. As the table shows, the number of APLs dropped significantly, reflecting a high degree of standardization within this ship class.

Table 1. Reduction in HM&E APLs from LHD 1 to LHD 7

Ship	Total APLs	Class-unique APLs	Fleet-unique APLs
LHD 1	5,143	810	252
LHD 7	4,437	193	36
Reduction in APLs	**14%**	**76%**	**86%**

Amphibious Transport Dock Ships

The LPD 17 amphibious transport dock ship program is an excellent example of "smart" standardization. The program uses its own standardization program plan and HEDRS, as well as a systems and equipment selection process in which standardization is one of several key evaluation criteria for optimizing ship performance and cost.

Detailed design of LPD 17 began in 1997, and the first of 12 ships is scheduled for delivery in November 2004. Construction of the lead ship, the USS *San Antonio*, is 50 percent complete. The program office has emphasized the reduction of TOC and set an internal goal of a 20 percent reduction in operation and support costs and shipboard manpower.

From the start, LPD 17 logistics and engineering communities have worked jointly in the selection of ship parts and components. Logistics experts and design teams have sought not only to capitalize on standard parts, but also to attain the best overall ship support picture based on emerging technology. Using both the standardization program plan and HEDRS, this approach married the evaluation of standardization, system requirements, technology insertion, customer input, human systems integration, and TOC.

LPD 17 production design is complete, but full provisioning and engineering documentation is not complete. Nonetheless, the equipment status for the LPD 17 is documented at 71 percent fleet standard and 29 percent nonstandard for contractor-furnished equipment, which excludes software, but includes HM&E equipment and some electronic equipment.[9] Parts previously considered electrical equipment are now integrated into HM&E equipment. (The distinction between the two equipment types will continue to blur.)

LPD 17 program decisions on equipment standardization fell into three primary categories:

- *Selection of Navy standard equipment.* An item is standard if it is supported in the Navy supply system. Standard equipment and components have complete technical documentation, including training, operation, and maintenance technical manuals, which have been approved by the Navy and are supported by the Navy or the original equipment manufacturer. The selection of Navy standard

Innovative Application of a Standard

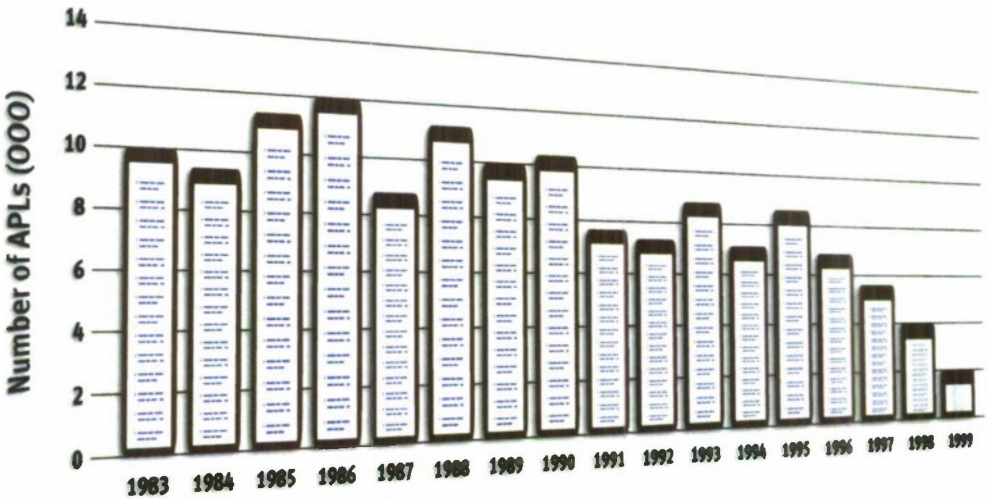
The baseline system description for the LPD 17's main propulsion diesel engine called for standard lube oil and fuel oil pumps with one attached pump and one electric pump per application. Attached pumps are more complex than electric pumps and require more maintenance. After determining that there was no valid requirement to operate without electric power, the program decided to use all electric pumps, which are standard equipment, in a nonstandard application. The Navy eliminated the need for two sets of repair parts and expects a life-cycle cost avoidance of $6 million.

equipment could take several forms:

- In some cases, LPD 17 logisticians and engineers chose to retain the originally prescribed standard equipment as called for in the baseline system description developed by Navy ship designers.
- In other cases, the program migrated to standard equipment when nonstandard equipment was originally prescribed.
- Alternatively, the program may have selected alternate standard equipment that improved performance and reduced TOC, while still remaining standard. For example, the program may have migrated to an alternate standard that the Navy had identified as an equipment improvement.
- Finally, the program may have chosen to use standard equipment in a nonstandard application.

- *Selection of commercial standard equipment.* In some instances, the program selected equipment that was already standard in the commercial fleet. Standardization statistics do not include those items that may not be standard in the Navy supply system, but are standard in commercial ships.

FIGURE 2. Number of HM&E APLs Introduced from 1983 to 1999



- *Selection of nonstandard equipment.* The program chose to incorporate nonstandard equipment wherever performance and cost benefits for the nonstandard equipment outweighed those of the standard equipment. (Examples of nonstandard parts are electronics, noncorrosive titanium piping, and fiberglass batting.) Standardization was one of several performance and cost factors, such as maintainability, supportability, readiness, and operational requirements.

Overall Fleet

According to FY00 data, the Navy supply system supports nearly 150,000 unique HM&E components—down 30,000 from 1988—representing $15 billion in government assets. Approximately 2,000 new repairable items were added in FY00—down 6,700 from 1988. Figure 2 shows the number of new HM&E APLs introduced from 1983 to 1999.

Although empirical data on the overall life-cycle cost savings and benefits attributed to standardization on the LHD and LPD ship classes do not exist, we can translate standardization results into savings by considering the initial and life-cycle costs associated with the introduction of a new item into the logistics support system.

Using the ILS cost calculator and assuming a conservative 5-year equipment life, the Navy calculated the

average ILS cost for the initial introduction of a new pump at approximately \$63,000. This figure excludes the price of training, which can run into tens of thousands of dollars, depending on the complexity of the equipment and other factors such as disposal costs. When calculating across all HM&E equipment categories, the Navy estimates that the ILS cost of introducing one new piece of equipment averages \$173,851. (This figure includes the cost of training, provisioning, NSN/APL maintenance, technical manuals, installation drawing changes, configuration control, and planned maintenance.) Therefore, if the Navy introduces 2,000 fewer new HM&E equipment items, it will save \$348 million in initial and life-cycle costs.

In addition to the ILS and provisioning savings realized from smart standardization, the Navy benefits in other ways:

- Improved operational readiness of the ship
- Reduced costs and manpower needed to operate and maintain the ship and its systems
- Optimized variety of items used in logistics support
- Enhanced interchangeability, reliability, maintainability, and availability, and products that meet quality and safety requirements.

Future Efforts

Although the Navy has focused its HM&E equipment standardization program on ship construction and conversion, depot maintenance and overhaul programs also present significant opportunities for standardization. As fewer new ships are built, the Navy is increasing its overhaul or extended life programs for existing ships.

The Navy hopes to encourage the selection of standard parts and to insert the use of HEDRS into the ship overhaul business. In particular, the Navy is working with naval shipyards to target the replacement of unique items when failed equipment is replaced or when a ship is overhauled. On the basis of FY00 data, nearly 20 percent of HM&E equipment was installed in a single fleet application (one-of-a-kind occurrence within the fleet), costing the fleet approximately \$5 billion in integrated logistics support.

Lessons Learned

Some of the lessons learned in the HM&E standardization program

Migration to a Commercial Standard

The LPD 17 baseline system description specified two nonstandard, 13-meter rigid hull inflatable boats (RHIBs) and one standard 7-meter RHIB. A 13-meter boat is not needed to satisfy operational requirements. So logistics experts, working with design engineers, chose an alternate system composed of two 7-meter RHIBs and one 11-meter RHIB, both commercial standard boats in the Navy supply system and in use in other Navy ship programs. The change not only will improve standardization across the fleet, but will result in a 12-ton topside weight reduction and a life-cycle cost avoidance of \$43 million.

might apply to other standardization programs:

- Unless accompanied by standardization incentives, acquisition of components as contractor-furnished equipment using performance-type specifications may result in unintended consequences: nonstandardization and proliferation of HM&E items.
- Monetary incentives alone are insufficient in supporting equipment decisions. To make the right equipment decisions, the program and design team must have access to equipment data.
- The effects of obsolescence and manufacturer turnover can be ameliorated by providing program managers easy access to current manufacturing data.
- Acquisition and engineering communities must raise the awareness of the impacts on logistics support costs of using nonstandard equipment. Engineers and managers should have easy access to standardization policies, data, and templates.
- Standardization for standardization's sake is not a best practice. Marrying smart standardization and best practices enables the evaluation of system requirements, technology insertion, TOC, and other factors, resulting in the best overall system support picture.
- Program managers must retain the flexibility to incorporate new equipment, when necessary, and strive to standardize on that equipment, as appropriate, in succeeding designs and construction.
- Documented progress reports on the level of standardization are critical tools in the standardization management process.
- Smart standardization can dramatically reduce TOC while improving performance, readiness, and interoperability. Standardization also reduces program risks of diminishing manufacturing sources and obsolescence.
- Although standardization has long been a major concern for the logistics community, changes in system acquisition and support practices and in management have shifted the burden and benefits of standardization to program managers and end-item manufacturers and suppliers.

Use of Emerging Technology

Standard shipboard stick masts are exposed to the elements, present a higher radar cross-section profile, and contribute to higher life-cycle costs for masts and mast equipment. By using a new composite enclosure—called the Advanced Enclosed Mast System—for both the masts and related antennas and equipment, the LPD 17 will have a reduced radar cross-section profile and reduced maintenance, resulting in an estimated $419 million in life-cycle cost avoidance for the class.

NOTES

[1]This HM&E standardization effort was led and executed primarily by the Naval Sea Logistics Center (NAVSEALOGCEN), Mechanicsburg, PA, with support and involvement of the Naval Supply Systems Command (NAVSUP), the NAVSUP HM&E Equipment Standardization Steering Committee, and the Naval Sea Systems Command (NAVSEA).

[2]An APL is a maintenance support document developed by the Navy for a specific system, equipment, or component. An APL identifies the maintenance-significant items of the equipment and the support items associated with the equipment's operation and maintenance. The basis for comparing the commonality of HM&E equipment is the APL number, which identifies a unique equipment type that requires distinct maintenance methods and spare parts provisioning. Therefore, the more a single APL number occurs throughout the fleet, the greater the standardization.

[3]"Ship type" refers to ships of the same purpose, for example, amphibious assault ship (general purpose) (LHA), amphibious assault ship (multipurpose) (LHD), and amphibious transport dock ship (LPD). "Ship class" refers to ships with the same primary design. For example, the LHD 1 ship class comprises the LHD 1 through LHD 7 hulls.

[4]SeaLink is an online equipment selection tool that allows end users to compare required form, fit, function, and performance requirements with readily available and supported commercial equipment and components.

[5]For the survey, done continually, NAVSEALOGCEN provides each manufacturer with known information on the manufacturer and its equipment. The manufacturer responds with updated information on what level of support it provides for each type of equipment, whether the equipment is commercial off-the-shelf, and who the manufacturer's point of contact is for each equipment type. If a merger or acquisition has occurred, NAVSEALOGCEN updates the database with the new equipment number and notes the former manufacturer.

[6]For example, an engineering support code of "A" means that the equipment and all associated spare and repair parts are available from the original equipment manufacturer.

[7]"Obsolete" means that the original manufacturer no longer manufactures the equipment, nor does it provide any spare or repair parts; "obsolescent" means that the manufacturer no longer manufactures the equipment, but it provides some or all spare or repair parts.

[8]LHD 7 was commissioned in July 2001.

[9]Government-furnished equipment (GFE) items are ship add-ons that are excluded from the design contract. For example, the ship's self-defense system is a GFE item. By definition, GFE items are standard items.